Relative space-time asymmetries in pion and nucleon production in non-central nucleus-nucleus collisions at high energies

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We propose[1] to use the the pion-proton correlation function to study the relative space-time asymmetries in pion and proton emission (pion and nucleon source relative shifts). We address the question of the non-central collisions, where the sources can be shifted spatially relative to each other both in the longitudinal and in the transverse directions in the reaction plane. To be specific, we investigate particle production in the rapidity region close to the projectile rapidity in Au+Au collisions at AGS energies.

We exploit the fact that the impact of the two body final state interaction (witch is responsible for the correlations) obviously is different for particles (at the instant of both of them are created) moving, in the particle pair rest frame, toward each other or moving in the opposite directions. If the centers of the effective sources of two particle species are shifted, then the correlation function depends on the orientation of the relative velocity with respect to the shift.

In the region of small values of relative momentum k^* the final state interaction is dominated by the Coulomb interaction. If we denote the correlation functions for two different cases, $k_i^* > 0$ and $k_i^* < 0$, as $R_i^{(+)}$ and $R_i^{(-)}$,

$$\frac{R_i^{(+)}}{R_i^{(-)}} \approx \frac{1 + 2\langle \mathbf{r}^* \rangle \langle \mathbf{k}^*/k^* \rangle^{(+)}/a}{1 + 2\langle \mathbf{r}^* \rangle \langle \mathbf{k}^*/k^* \rangle^{(-)}/a} \approx 1 + 2\langle \mathbf{r}^* \rangle_i/a$$

where a is the Bohr radius (for the $\pi^{\pm}p$ system $a \approx \pm 222$ fm) and $\mathbf{r}^*$ is the relative separation in particle production points. Then, $\langle \mathbf{r}^* \rangle$ is the shift between sources in the pair rest frame, the quantity of interest[2]. In accordance with the above equation, each one fermi of the shift leads to a change of approximately 0.9% in the ratio of the corresponding correlation functions at small values of k^*.

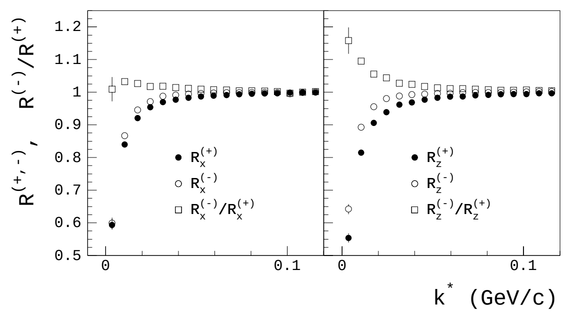

Figure 1: The correlation functions $R_{x,z}^{(+)}$ ($k_{x,z}^* > 0$) and $R_{x,z}^{(-)}$ ($k_{x,z}^* < 0$) for the event subsample "$\Psi_r = 0$".

We use the RQMD event generator to simulate Au+Au collision. We select *particles* in the region $2.8 < y_{lab} < 3.2$, and create two event subsamples in accordance with the orientation of the reaction plane: "$\Psi_r = 0$" and "$\Psi_r = \pi$".

In figure 1 we show the correlation functions calculated for the "$\Psi_r = 0$" event subsample for two sets of cuts $k_x^* > 0$ ($k_x^* < 0$) and $k_z^* > 0$ ($k_z^* < 0$). One can see that the correlations are stronger in the cases of $k_z^* > 0$ and $k_x^* > 0$, which clearly indicates that the proton source is shifted relative to the pion source to positive z^* and positive x^* values. The magnitude of the difference in the cases of cuts on k_z^* and k_x^* shows that the shift in z direction is larger than the one in x direction.

Footnotes and References

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[2] More discussions can be found in Ref. [1] and R. Lednicky, V.L. Lyuboshitz, B. Erazmus, D. Nouais, Phys. Lett. **B373**, 30(1996).